An overview of technological advancement in Mobile-based Augmented Reality using Mobile edge computing and 5G

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Abstract: Mobile-based augmented reality (MAR) is gaining more popularity due to the advancement in the intelligent Smartphones which are having features and hardware requirements for implementing augmented reality (AR), Mobile based segmented reality is an innovative technique of adding, overlaying the digital assets onto the real scene when the user's device's camera is pointed out at real environment for detection and renders the digital content. This paper provides a conceptual understanding of the technological advancement in the AR and also discusses the growing development tools to measure the competency along with challenges as well as the future scope to establish the proficiency among other technologies making it more vigour and reliable for end-users across the globe. We examine the latest trends that are reflected in network technologies like 5G in conjunction with powerful platform Mobile edge computing (MEC) to offer high bandwidth when the edge servers exclusively scale down the network constraints to help reduce the bandwidth strictness of the network by acting closer to the user. Furthermore, it removes the drawback of latency issues when the data is being handled in real-time closer to the users that may restrain the extensiveness of AR.

Keywords: Augmented reality. Bandwidth Limitation, Mobile-based augmented reality, Mobile Edge Computing (MEC), 2D/3D content, 5G.

I. INTRODUCTION

Mobile-based augmented Reality is a prevailing technology that simplifies the real world by supplementing layers of digital content onto it. These contents embrace computer-generated graphics, sensory activities, sound or video inducement, or haptic evaluation. The term augmented reality (AR) was first framed by "Thomas Caudell and David Mizell in 1992. The process of superimposing 2D/3D digital content in the real world simulates the geometric alteration of real objects in AR applications, by blending them with an authentic purposely-transformed replica of it [1]. AR attributes to a technique commenced form virtual reality. The purpose behind computing this digital knowledge is to implement intriguing and effective participation that is facilitated with the input collected from varied hardware like Smart phones, Smart lenses, and Smart glasses [2]. At the same time also calculating distance of these objects from the main object in focus. The manageable procedure is employing a Smartphone - where a user sees through the camera has digital content combined onto it. The data can be 2D or 3D depending upon the requirement. Smartphones are gaining popularity all around the globe with their tremendous features and with the help of inbuilt digital cameras, music players, accelerometer, gyroscope as well as other PDAs, all of them are ready to be the success of the mobile computing paradigm platform becoming the popular choice for many people in the future deploying it successfully [3]. AR can be practiced using marker-based where the device detects marker by pointing the camera and display the digital assets thereafter, marker-less based AR is done using GPS to register virtual information on real space, digital compass, and accelerometer while predicting where the user is focusing, projection-based AR where light is manipulated against the surface and the communication is done by touching the projected area using hand [4] Quite effective experience can be made by the user. Authenticating the user allotment relatively in articulation on the user data to persuade an identity of the user and to consider that the user has the privilege to access a remote computing structure [5]

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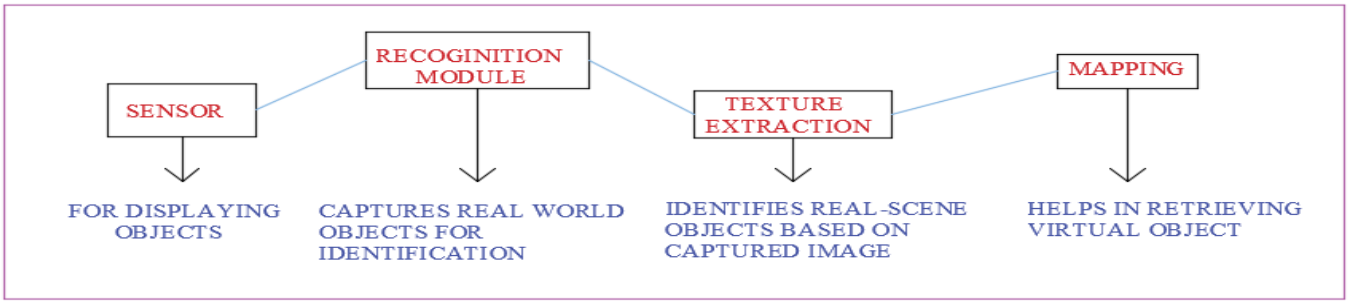

Figure 1. Process of Mobile Augmented Reality

When a user views and tries to capture an image, the following steps needed to be fulfilled the sensors like camera, accelerometer, and gyroscope helps in overlaying the digital 2D/3D content. A texture extraction tries to extract the texture of the real-scene objects based on the image being shown or captured by sensors. A recognition module does the identification of the objects in the real-world based on the captured image. Mapping is the technique by which it retrieves the digital object related to the identified real-scene image; the objects are placed or mapped onto the captured image in real time. And makes the visualization of the identified real-world object in a virtual mode for displaying on the user's device.

This study aims to examine a significant overview of the literature review on AR display with development tools, we explore the research on modern AR experiences in order to identify specification hindering its availability, and it also provides a relationship framework of Mobile edge computing and 5G with AR. It highlights to resolve the bandwidth issue that limits its features.

II. BACKGROUND

This section explores the relevant research background about augmented reality in relation to mobile devices with other features as well. Augmented Reality has been among us for many years in various forms.

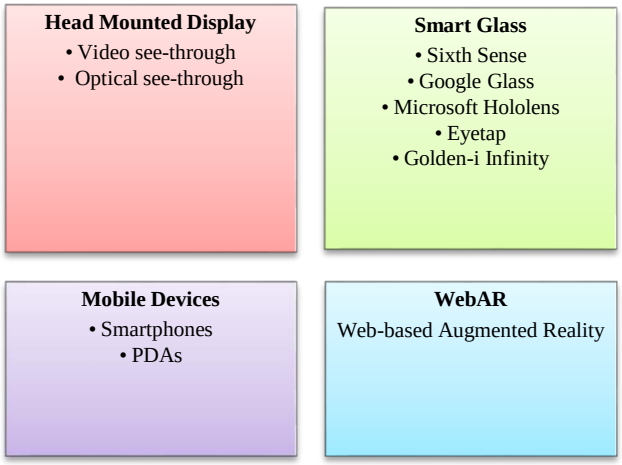

Figure 2. Different formations of AR

The first usage of AR was done using a Head Mounted Display (HMD) worn over the head; later in 2014, project glass came into existence having the shape of an eyeglass with the capabilities to show the contents of a Smartphone. In 2016, a mobile-based augmented reality game became the success named Pokémon GO that opened the doors for the evolution of MAR. After the success of MAR applications, the developers are trying to put and include AR on their websites.

Many other developers and companies are working for better and efficient tools for implementing and blending all the features that the technology and user may want like Google and Apple are trying to make even better tools than the ones previously provided by them to help user gain all of the features and creation effortlessly. Along with these other companies and developers are also putting effort into providing the best for the users to implement and take effective usage developing major environments to fully evaluate the circumstances while viewing AR. Below are the various formations that AR made so far:

A. Development Tools

Among various development tools made so far following are the tools made by various organizations Vuforia is specifically one of the outstanding tools for reinforcing applications based on Augmented Reality. It supports all the primary platforms along with Android and iOS. It supports several objects like boxes, toys, images, etc. And also provides text recognition. [6] ARToolKit is a prominent open-source tool, even though vitally charge less to use application and it still incorporates a couple of the leading features originated in top paid tools. ARCore is an absolutely valuable tool that works with unreal, utility, and Java. Part of the specialty of ARCore includes Monitor tracking, Environment awareness, Light evaluation, and interpretation, etc. Google AR supports approximately entirely all the android devices running on 7.0 or higher version. The ARkit was released in July 2017, and it solely supports iOS devices. The main features of Apple ARKit comprised of VIO or Visual Inertial Odometry, Face Tracking, Tracking light levels, etc. MAXST incorporates QR, and barcode tracking, Extended Image tracking and Utility Plug-in Integrations. It works on Windows, iOS, Android and macOS shaping it as a splendid tool. Kudan is roughly identical to Vuforia in specifications of its features. Xming is a toolkit that's constructed in Hong Kong. The

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tool is distinctively anticipated for face tracking and it does its operations altogether.

Table 1. Comparison of Development Tools

SDK	Platform	mart glasses Support	Unity 3D	SLAM	Price	Type	Cloud Recognition
Vuforia	iOs,Andriod, Windows	Yes	Yes	Yes	Free, Commercial	SDK	Yes
Kudan	iOs.Android	-	Yes	Yes	Free. Commercial	SDK	-
ARcore	iOs,Android	Yes	Yes	Yes	Free	Framework	-
EasyAR	iOs, Android, Windows	-	Yes	-	Free, Commercial	SDK	Yes
ARtoolkit	iOS, Android, Windows, OS X, Linux	Yes	Yes	-	Free	Framework	-
Maxst	iOs.Android, Windows	Yes	Yes	Yes	Free, Commercial	SDK	Yes
LayarSdk	iOs,Android	-	Yes	Yes	Free, Commercial	SDK	Yes
Lumin	Lumin OS	Yes	Yes	Yes	Free, Commercial	SDK	Yes
Pikkart	iOs, Android	Yes	Yes	-	Free, Commercial	SDK	Yes

B. Standard AR Experiences

i. Shopping and Retail: AR permits to try on a watch, a shirt/ inspect several products a user may wish to have shaping it easy to assimilate digital assets within the world all over. The user has full advantage of before going out and buying any essential for himself to check it and then making any further decision.

ii. Business: Warehouses can frame supportive navigation and guidance for workers to find out the areas in a big firm and complete the task in a given time or before time. Architecture enterprise can flourish designs in the 3D range.

iii. Social Media: Snapchat was the primeval media platform to perfectly affiliate AR. The platform acquaints lenses in 2015, which elevated the demand for filters. Facebook also acclaimed the direction with its camera-fixed spot. Many platforms are framing AR for catching the users' eye and making it more comfortable for the user as well.i

iv. Gaming: In 2016, Pokémon Go emerged the first mobile-based augmented reality game which outburst its enormous features and user involvement gaining popularity all over the world. Location-based experience games like this are an only achievable application of AR as many companies are working on implementing AR for user satisfaction and involvement.

v. Education: Demonstrating complicated subjects could be convenient as students can analyze a strand of DNA. Dimensional learning allows students to employ with 3D content. [7] Different applications have been made to help students understand and score well with the user involvement giving the students a hint of what actually is there in the research to help understand them.

vi. Healthcare: Doctors and nurses are practicing AR enriched solution facilities to more successively diagnose patients, strategize procedures, and methods. Many doctors have been using AR to successfully implement surgeries.

II. LITERATURE SURVEY

Based on previous studies and practical knowledge following are the information gained by different studies so far and focus can be made on some of the studies:

Augmentation is an ability to take advantage of AR on mobile devices to build up real-world productive activities, support discipline, and open new cooperative prospects. It has removed the partition between physical and digital by collaborating with the computer as common as interacting with real-world objects to make everyday task easier for the end-users. [8]. Exploring the intelligence and finding out that HMDs add in the stationary displays making little immersive but can be viewed by multi-users while the hand-held devices are easy to look at so that the users can view any digital content while even moving or walking. The technology can be used to display digital content onto the real world by providing a direct/in-direct view of the real world [9]. Smartphone has been ascending to a new peak from past few years and has more user involvement making it easier to incorporate AR related activities gathering a lot attention as possible [10]. A mobile game Pokémon GO based on augmented reality was released and resulted in a breakthrough which pushed the development of AR. The software analyses, the marker-based AR

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generates a virtual image superimposed on the mobile phone's display, fixed to the point of the camera. This means the app works with the camera to interpret the angles and distance, the mobile phone is away from the marker [11]. Marker-based applications and Location-based/ Marker-less applications are the two types of AR. The former is based on image recognition. These types of apps are working on a marker containing black and white color to present the AR contents. The marker-less based uses GPS technology and not makers. It uses the accelerometer, GPS, or compass of Smatphones to detect the location. For tracking, a digital camera or optical sensors like GPS, RFID can be used also to input the data there are techniques to incorporate speech acceptance and detection system that converts a user's spoken words into computer information/ expression recognition [12]. The possibilities of AR tech are limitless. The absolute doubtfulness is effortless and rapidness that the developers will incorporate these potential into modern devices for being able to handle them often. Two influential tech rulers Apple and Google continue to twist their mobile devices to examine the proposal of AR-definite software, those devices will adequately send and receive incredible volume of data. Acquiring information with multiple senses and ideally the whole body which is an approach that requires proper attention to be successfully unpacked [13]. Google jumped into AR development in the first quarter of 2018 with its ARCore platform for building augmented reality experiences. Using different APIs, ARCore enables a user's phone to sense its environment, understand the world, and interact with information [14]. There are a variety of intelligent interactions, including hardware device interactions, location interactions, tag-based, or other information-based interactions. With the progress of knowledgeable interactive technology, the augmented reality is not solely overlaying virtual content onto real-scenes but also has improved with realizing the alteration among users and virtual objects in real-world [15]. In the last few years, academics and practitioners have focussed on various possible ways that the shopping experience can be improved and store environments can become more fascinating for consumers [16]. Previous research studies elaborates how the trending technologies are taking part in the market and showing their importance of AR-applications on the student's learning activities, involvement, and motivation as well [17]. After the evolution of Google Glass which is a head-mounted device mainly connected with a Smartphone for internet relatedness and access to the Android Operating System where all the activities of the mobile device can be done on the Google Glass instead but a lot more changes have been done to make it fully owned by the users for future readiness [18]. The headsets are also resulting in a great acceptance for the consumers these devices often has heavy usage and complex interaction, for gaming as well headsets has really good interaction possibilities. Sometimes these devices stop working due to heavy consumption and are also responsible for motion sickness [19].

Table 2. Inference of the Literature Review

AUTHOR	YEAR	TITLE	OUTCOME
Billinghurst, M., Clark, A., & Lee, G.	2015	A survey of augmented reality.	The digital and physical world has now a thin layer by relying on the latest technologies like AR.
Schmalstieg, D., & Hollerer, T.	2016	Augmented reality: principles and practice	The very first device to be used for augmentation was Head Mounted Display (HMDs). The headset used has advantage of experiencing real-world scene by walking as well.
Ling, H.	2017	Augmented reality in reality	Advancement in the Mobile devices over the past few years has evolved a lot that can be used to incorporate AR technology in it. By this, every single user will be able to take profit of experiencing live direct/ in-direct view without having to buy any other device.
Chatzopoulos, D., Bermejo, C., Huang, Z., & Hui, P.	2017	Mobile augmented reality survey: From where we are to where we go.	Different applications are now integrating AR making it more attractive. Initially, Pokémon GO was the first game that turns out to be effective for gaining users attention.
Mokhtar, M. K., Mohamed, F., Sunar, M. S., Arshad, M. A. M., & Sidik, M. K. M.	2018	Development of mobile-based augmented reality colouring for preschool learning.	Two of the basic types to experience this technology is to use marker-based and marker-less based technology.
Gandolfi, E.	2018	Virtual reality and augmented reality.	Apple and Google are trying every aspect to develop tools making it more efficient and reliable for the customer.
Voinea, G. D., Girbacia, F., Postelnicu, C. C., & Marto, A.	2018	Exploring cultural heritage using augmented reality through Google's Project Tango and ARCore.	ARCore was the first SDK developed by Google in the early 2018.
Chen, Y., Wang, Q., Chen, H., Song, X., Tang, H., & Tian, M.	2019	An overview of augmented reality technology	A lot can be experienced through this interactive technology as there is hardly difference between real and digital world.
Caboni, F., & Hagberg, J.	2019	Augmented reality in retailing: a review of features, applications and value.	Lately. Industries along with learning education is also taking their part in AR to save time, understand and have knowledge of different things in the real-world easily.
Bhagat, K. K., Liou, W. K., Michael	2019	To use augmented reality or not in	Now education centre are also merging AR in their learning

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Spector, J., & Chang, C. Y.		formative assessment: A comparative study.	strategy for students to be able to get clearer about problematic theories.
Berger, A., & Maly, F.	2019	Smart Google Glass Solution Used as Education Support Tool	Google initially introduced Google Glasses that turned out to be a great success later it realised SDK to put together with mobile devices.
Miller, M. R., Jun, H., Herrera, F., Yu Villa, J., Welch, G., & Bailenson, J. N.	2019	Social interaction in augmented reality	Headsets are losing their importance due to their heavy consumption and lagging.

IV. PROBLEM FORMULATION

The expansion of the mobile industry has contributed to the growth of AR due to the components required are already available in present-day Smartphone's, it is easily implemented on them. Thus, the subsequent ordinance requires to be taken to overcome the future issues of the expeditious growth of data. [20] The foremost problem is to speed up the computation of tasks being performed during the execution of AR technology on a device and that can only be done as well as accumulated by employing higher bandwidth interpretation as using other devices may not work properly due to complexity. Some discussion on relevant papers showed that the use of mobile cloud computing will help remove the bandwidth limitation as well as service availability, heterogeneity, and security.

While cloud computing in comparison to mobile edge computing is doing far better. 5G could remarkably simplify in millimeter waves to clear up the bandwidth drawback found in a regular networks. A specific approach to draw about the problem (shortfall of bandwidth) is to

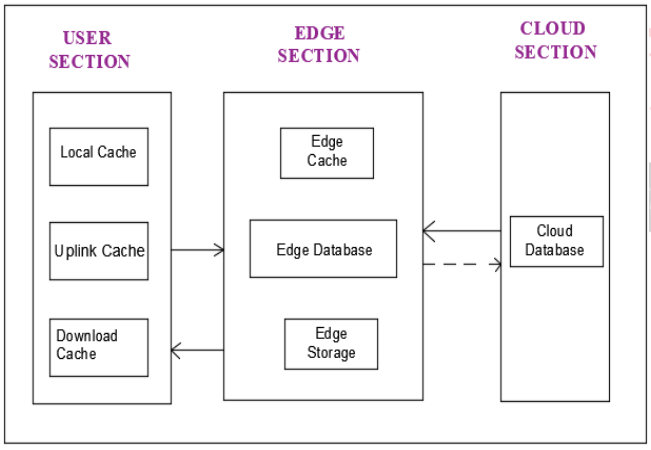

Figure 3. MEC-based AR working

User layer is accountable for carrying out local operations like sensing direct/ in-direct view in real time via camera and sensors. The mobile device will transmit the data in the uplink cache to the edge layer through wireless connection. The data at the user side is duplicated in the form of two copies, one is stored at the local cache for further processing and the other one is stored at the uplink cache. Both uplink cache and local cache plays an important role in maintaining the data at the user terminal.

The edge layer helps in computing AR application by receiving requests when the user asks for image-matching and retrieval of data. It receives the user's operation, instructions, and then delivers them to the edge cache for separate storage. It does the computing of stored data at the edge storage. All the process of classification, feature-point extraction, and mapping happen at the edge layer. When the image is matched with the captured image then the resulted image is stored at the edge storage for sending it to the user via wireless connection.

The cloud layer helps n identifying and matching of the images that are not found at the edge side. After successful feature matching, the results are being sent to the edge server and then the edge section sends back the resulted data to the user cache for rendering and displaying of the data.

directly disseminate signals on a totally new spectrum, one particularly not at all been used for mobile service before. The user involvement will be prodigious with a decreased lag time.

V.HOW MEC PLAY AN IMPORTANT ROLE TO PULL UP AUGMENTED REALITY

In recent studies, we have found out that it takes delivery of a 3D model or rendering of 3D model while viewing AR content on the end-devices which is a heavy computational task and cannot meet efficiency by using in the cloud only, therefore there is a need to implement MEC that provides real-time processing and rendering of data at the edge and closer to the user. With 5G, it is meant to deliver higher multi-Gbps peak data speeds, ultra-low latency, more reliability, massive network capacity, increased availability, and more uniform user experience to more users. Advanced performance and proficiency empower new user experiences and associate new industries.

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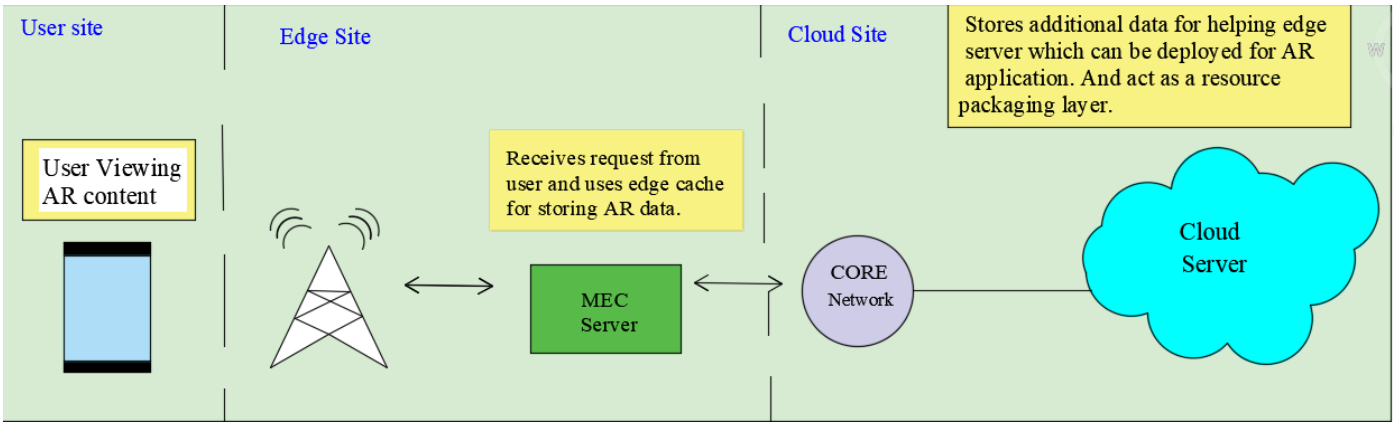

. Figure 4. 5G with MEC for utilization of efficient Augmented Reality

This framework works in the form of three sections first is the user or terminal section, second is the edge-server section and third is the cloud-server section.

The user or terminal section is capable of operating local tasks. When the user points the camera onto the real-world, the data is captured via the user's device's camera and sensors. After the identification is done the data about identified information and analysis of the identified data is processed. Hence, this data is uploaded into two files one is the uplink cache for transmission of data and the second is the local cache for subsequent processing.

The edge section is mainly responsible for acting as the service request layer in the framework by implementing the necessary processes to authenticate the user and to enable all the service requests which are implemented at the edge side and perform incoming service request. . For manageable service or some informational requests, a request-response model can be convenient. For enlarged processes, the framework further supports a feasible subscribes-notify model. MEC facilitates a network to implement the computed, storage, and cache efficiency at the edge. Data is handled, saved, and distribute locally, without making the network center involvement. All of the user's data and instructions are delivered to the edge cache for storage purposes. The tracking as well as mapping for displaying digital content is handled with the help of algorithms namely, simultaneous localization and mapping (SLAM) and parallel tracking and mapping (PTAM). When the image is matched after image retrieval, the subsequent information is obtained from the edge server.

The cloud section helps in maintaining the database for storing data information when it is not handled at the edge section due to its storage size. Furthermore, images that are matched conveniently on the edge cloud server will also be conveyed to the cloud server section for storing the related information. The corresponding data about image matching is also stored at the cloud side. The edge side makes a connection to the cloud side for implementing more complex tasks and transmit back to the edge server. Finally, the data is given to the user's device after executing all these tasks.

VI. FUTURE DIRECTIONS

Screen-less providence will readily grow into a reality. Since respective wearables will be pervasive, so any future breakthrough will fill in up-gradation on the screen. Gestural attachment is desirable that humans can adapt and benefit alongside their body expressions and actions to control technology so that the efficiency of the device while viewing AR as a novel way becomes more desirable. It will reformulate an immersive human-technology interconnection which conclusively leads to a ubiquitous foreknowledge of the enhanced and improved technologies in the field of computer science. With the improvement in the technologies like Internet of things (IoT) and Artificial Intelligence (AI), the greater addition to augmented reality as an empowered solution will result in the evolution of the opportunities as all of them are the new trends in the technology for facilitating user satisfaction and involvement in delivering the economic and productive solutions by acting as well as enabling the more realistic and impressive experience. The time-consumption process could be handled more effortlessly with the use of AI.

V. CONCLUSION

The reflection of Augmented Reality is breaking the reach to turn out as the solution to future problems. There are so many decisive advantages leading to the foundation of a solution to everyday problems. It improves the interaction with the user. This study reveals the closure and shows that many of the drawbacks can be moderately relieved by new originating 5G wireless technology along with the MEC framework integrated for taking profit from augmented reality. Considering the network profit by integrating it with the AR makes the optimization and utilization more powerful. This analysis also acknowledges research and development accomplishment in examining the availability of mobile AR with 5G network are relevant involvement to contribute to our discovery of the challenges, probability, and future guidance will be able to enlighten

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more research interests and efforts on delivering life-enriching.

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